P037444/WO/1 2/PRTS 10/538048 JC17 Rec'd PCT/PTO 08 JUN 2005

DaimlerChrysler AG

Method for regulating an air conditioning system for a vehicle with closeable openings in the bodywork

The invention relates to a method for regulating an air conditioning system for a vehicle with closeable openings in the bodywork according to the preamble of patent claim 1.

Current regulating concepts for air conditioning systems of open vehicles usually only take into account whether the convertible top is closed or opened.

For example, DE 38 43 898 C2 has disclosed a method for heating a vehicle in which a distinction is made between operation with the vehicle closed and operation with the vehicle opened. When the vehicle is closed, the heating system is controlled using the parameters of ambient temperature, setpoint interior temperature, actual interior temperature and, if appropriate, the speed of the vehicle. A regulating process is carried out only when there is a change in the interior temperature over time. When the vehicle is opened, a regulating process of the blowing out temperature is carried out, i.e. ambient conditions and the like are not taken into account.

DE 195 44 893 C2 has also disclosed additionally taking into account as regulating parameters of an air conditioning the solar radiation, namely its direction and intensity, which is sensed by a sensor for sensing the solar state.

With the known methods for air conditioning it is thus not possible to implement a regulating process which is adapted to the ambient temperatures and to the speed of the vehicle and therefore air conditioning which is comfortable in terms of temperature for the vehicle

occupant or occupants since when a convertible top is opened the system is simply switched over to regulating the blowing out temperature and the speed of the vehicle and ambient conditions are not taken into account in this regulating process.

The object of the present invention is therefore to configure a method for regulating an air conditioning system for a vehicle with closeable openings in the bodywork, with which it is possible to achieve an air conditioning process which is adapted to the ambient conditions and the speed of the vehicle and is comfortable in terms of temperature for the vehicle occupant or occupants irrespective of the position of the convertible top.

This object is achieved according to the invention by means of a method for regulating an air conditioning system for a vehicle with closeable openings in the bodywork as claimed in claim 1. Advantageous developments of the invention are specified in the subclaims.

These and further objects, advantages and features of the invention are apparent from the following description of a preferred exemplary embodiment of the invention in conjunction with the drawing. In said drawing:

Fig. 1 with fig. 1A and fig. 1B shows a flowchart of the air conditioning method according to the invention.

In the text which follows an air conditioning method according to the invention for a vehicle with closeable openings in the bodywork will be described in more detail with reference to figure 1, which is divided into figs 1A and 1B, with which method a state which is comfortable in terms of temperature for the vehicle

occupant or occupants can be brought about with the vehicle closed or opened.

In order to provide an air conditioning system which is comfortable in terms of temperature for the vehicle occupant or occupants irrespective of a position of a convertible top and of the speed of the vehicle, in the method according to the invention, in contrast to the prior art, various information is used as a regulating parameter when the convertible top is opened. When the convertible top is closed, the conventional, comfortable air conditioning is carried out. In contrast, when the convertible top is opened, in addition to the information about the ambient temperature, solar radiation (direction and intensity), setpoint interior temperature and actual interior temperature, which is conventionally used for air conditioning with a closed convertible top, in the method according to the invention the speed of the vehicle is also taken into account for regulating an air conditioning system for a vehicle with closeable openings in the bodywork since the speed of the vehicle has a significant influence on the comfort of the vehicle occupants in terms of the temperature. The speed of the vehicle is advantageously determined by means of the sensors which are used in any case for regulating the vehicle dynamics in the vehicle. The sensors for sensing the solar radiation and the ambient temperature are already present from the conventional air conditioning system. For this reason, no additional sensors are necessary so that the method according to the invention improves comfort or reduces consumption in a cost-effective or cost-neutral way.

In the regulating process according to the invention, a state of an opening the bodywork is firstly sensed in a step S0, i.e. it is determined whether the vehicle is closed or opened. If the vehicle is closed, a

conventional air conditioning method is carried out taking into account the parameters of ambient temperature, setpoint interior temperature, actual interior temperature and solar radiation. However, in the case of an opened convertible top the method according to the invention which is described below with reference to figure 1 with fig. 1A and fig. 1B is carried out in order to regulate an air conditioning system.

The regulating process according to the invention comprises, as shown in figure 1, regulating sections which take into account the sensed parameters of solar radiation, ambient temperature and speed of the vehicle in the regulation of the blowing out temperature and of the mass flow. These regulating sections will be explained separately below and can either be implemented simultaneously or in chronological succession.

In the conventional blowing air regulating process, air is blown out with a constant, predefined air mass flow rate M_N and a blowing out temperature θ_{AN} which is determined in accordance with a preselected (by the user) setpoint temperature. In contrast, in the method according to the invention for air conditioning both the air mass flow rate and the blowing out temperature are regulated, and if there is a nozzle with a blowing direction which can also be regulated electrically, this is also regulated. The starting basis for the regulating process are the constant, predetermined air mass flow rate M_N and the blowing out temperature θ_{AN} predetermined in accordance with the preselected setpoint temperature, for each of which values a solar standard radiation value, a standard ambient temperature and a standard speed are predefined and these are used as comparison values if the solar radiation, the ambient temperature and/or the speed

have not been measured until then.

Change in the solar radiation Δq

If a rise Δq in the solar radiation in comparison with a previously sensed solar radiation value is sensed (step Q1), the blowing out temperature θ_A is reduced by a value θ_{Aq1} and the air mass flow rate M is kept constant (step Q2). If this reduction in the blowing out temperature θ_A by the value θ_{Aq1} is not sufficient to compensate an increase in temperature by the rise Δq in the solar radiation (step Q3), to provide support, the air mass flow rate M is increased by a value M_{q1} (step Q4). In the case of heating it is alternatively also possible (not shown) for only the air mass flow rate M to be reduced by a value $M_{q1'}$ and for the blowing out temperature θA to be kept constant.

If a drop $-\Delta q$ in the solar radiation in comparison with a previously sensed solar radiation value is sensed (step Q1), the blowing out temperature θ_A is increased by a value θ_{Aq2} and the air mass flow rate M is kept constant (step Q5). If this increase in the blowing out temperature θ_A by the value θ_{Aq2} is not sufficient to compensate a reduction in temperature as a result of the drop $-\Delta q$ in the solar radiation (step Q6), in order to provide support, the air mass flow rate M is increased by a value M_{q2} (step Q7). In the case of cooling it is alternatively possible (not shown) for only the air mass flow rate M to be reduced by the value $M_{q2'}$ and for the blowing out temperature θ_A to be kept constant.

Change in the ambient temperature $\Delta\theta_U$

If a rise $\Delta\theta_U$ in the ambient temperature in comparison with a previously sensed ambient temperature is sensed (step T1), the blowing out temperature θ_A is reduced by

a value $\theta_{A\theta1}$ and the air mass flow rate M is kept constant (step T2). If this reduction in the blowing out temperature θ_A by the value $\theta_{A\theta1}$ is not sufficient to compensate an increase in temperature as a result of the rise $\Delta\theta_U$ in the ambient temperature (step T3), in order to provide support, the air mass flow rate M is increased by a value $M_{\theta1}$ (step T4). In the case of heating it is alternatively possible (not shown) for only the air mass flow rate M also to be reduced by the value $M_{\theta1}$, and for the blowing out temperature θ_A to be kept constant.

If a drop $-\Delta\theta_U$ in the ambient temperature in comparison with a previously sensed ambient temperature is sensed (step T1), the blowing out temperature θ_A is increased by a value $\theta_{A\theta2}$ and the air mass flow rate M is kept constant (step T5). If this increase in the blowing out temperature θ_A by the value $\theta_{A\theta2}$ is not sufficient to compensate a reduction in temperature as a result of the drop in the ambient temperature $-\Delta\theta_U$ (step T6), in order to provide support, the air mass flow rate M is increased by a value $M_{\theta2}$ (step T7) (case of heating). In the case of cooling it is also alternatively possible (not shown) for only the air mass flow rate M to be reduced by a value $M_{\theta2}$, and for the blowing out temperature θ_A to be kept constant.

<u>Change in the speed Δv of the vehicle</u>

If there is a change in the speed Δv of the vehicle, a differentiation is made between a case of "heating" and a case of "cooling". Whether a case of "heating" or "cooling" is occurring is dependent on the ambient temperature, on the sucked-in ambient temperature in the recirculation mode, on the solar radiation, the actual interior temperature and the setpoint interior temperature.

"Heating"

If a rise Δv in the speed of the vehicle in comparison with a previously sensed speed is sensed (step V1-H), the blowing out temperature θ_A is increased by a value θ_{Av1} and the air mass flow rate M is kept constant (step V2-H). If this increase in the blowing out temperature Δ_A by the value Δ_{Av1} is not sufficient to compensate a reduction in temperature by the rise Δv in the speed of the vehicle (step V3-H), in order to provide support, the air mass flow rate M is increased by a value M_{v1} (step V4-H). As an alternative to increasing the blowing out temperature θ_A by the value θ_{Av1} and keeping the air mass flow rate M constant it is also possible for only the air mass flow rate M to be increased by the value M_{v1} and for the blowing out temperature θ_A to be kept constant.

If a drop $-\Delta v$ in the speed of the vehicle in comparison with a previously sensed speed of the vehicle is sensed (step V1-H), the blowing out temperature θ_A is reduced by a value θ_{Av2} and the air mass flow rate M is kept constant (step V5-H). If this reduction in the blowing out temperature θ_A by the value θ_{Av2} is not sufficient to compensate an increase in temperature as a result of the drop in speed Δv of the vehicle (step V6-H), in order to provide support, the air mass flow rate M is reduced by a value M_{v2} (step V7-H). As an alternative to reducing the blowing out temperature θ_A by the value θ_{Av2} and keeping the air mass flow rate M constant it is also possible only for the air mass flow rate M to be reduced by a value M_{v2} and for the blowing out temperature θ_A to be kept constant.

"Cooling"

If a rise Δv in the speed of the vehicle in comparison with a previously sensed speed is sensed (step V1-K),

the blowing out temperature θ_A is increased by a value θ_{Av3} and the air mass flow rate M is kept constant (step V2-K). If this increase in the blowing out temperature θ_A by the value θ_{Av3} is not sufficient to compensate a reduction in the temperature as a result of the rise Δv in the speed of the vehicle (step V3-K), in order to provide support, the air mass flow rate M is reduced by a value M_{v3} (step V4-K). As an alternative to increasing the blowing out temperature θ_A by the value θ_{Av3} and keeping the air mass flow rate M constant it is also possible for only the air mass flow rate M to be reduced by the value M_{v3} and for the blowing out temperature θ_A to be kept constant.

If a drop $-\Delta v$ in the speed of the vehicle in comparison with a previously sensed speed of the vehicle is sensed (step V1-K), the blowing out temperature θ_A is reduced by a value θ_{Av4} and the air mass flow rate M is kept constant (step V5-K). If this reduction in the blowing out temperature θ_A by the value θ_{Av4} is not sufficient to compensate an increase in temperature as a result of the drop in the speed Δv of the vehicle (step V6-K), in order to provide support, the air mass flow rate M is increased by a value M_{v4} (step V7-K). As an alternative to reducing the blowing out temperature θ_A by the value θ_{Av4} and keeping the air mass flow rate M constant it is also possible for only the air mass flow rate M to be increased by a value M_{v4} and for the blowing out temperature θ_A to be kept constant.

A change value for the blowing out temperature and a change value for the air mass flow rate are subsequently formed from the values θ_{Aq1}, θ_{Aq2}, $\theta_{A\theta1}$, $\theta_{A\theta2}$, θ_{Av1} to θ_{Av4} and M_{q1}, M_{q2}, $M_{\theta1}$, $M_{\theta2}$, M_{v1} to M_{v4}, with the values for the increase being added and the values for the reduction being subtracted. The regulating process of the air conditioning system is then carried out in accordance with the resulting optimized change values

for the blowing out temperature and the air mass flow rate (step S8).

In addition to the above change values θ_{Aq1}, θ_{Aq2}, $\theta_{A\theta1}$, $\theta_{A\theta2}$, θ_{Av1} - θ_{Av4} and M_{q1}, M_{q2}, $M_{\theta1}$, $M_{\theta2}$, M_{v1} - M_{v4}, it is also possible to take into account a vehicle-occupant-dependent correction value which is, inter alia, also dependent on the degree of activity and/or clothing and is then combined additively or subtractively with the optimized blowing out temperature and the optimized air mass flow rate. This value can either be set manually or determined by adaptive operative control in response to subsequent adjustment by the user.

It is to be noted that in all the regulating situations at low speeds the air mass flow rate M tends to be reduced or kept constant owing to the resulting noise load and the adaptation is carried out by means of the temperature. It is thus also possible to reduce the air mass flow rate and bring about greater adaptation of the blowing out temperature instead of the keeping the air mass flow rate constant. Furthermore, it is to be noted that a change in the mass flow rate can take place more quickly than a change in the blowing out temperature.

The respective quantitative values θ_{Aq1}, θ_{Aq2}, $\theta_{A\theta1}$, $\theta_{A\theta2}$, θ_{Av1} to θ_{Av4} and M_{q1}, M_{q2}, $M_{\theta1}$, $M_{\theta2}$, $M_{q1'}$, $M_{q2'}$, $M_{\theta1'}$, $M_{\theta2'}$, M_{v1} to M_{v4} are vehicle-dependent. The associated profile curves can be determined by means of measurements on the vehicle.

In one preferred development of the air conditioning method according to the invention, upper and lower threshold values are additionally defined for the solar radiation q, the ambient temperature θ_U and v. For parameters values lying between these upper and lower threshold values, the profile curves mentioned above

are accessed, i.e. an actual value for the regulating process is taken into account. Above the upper or below the lower threshold value, the upper or lower threshold value is used for the access to the profile curves since in these regions a regulating process can no longer be carried out or can no longer be perceived by the user to an extent which corresponds to the effort. For example, the limiting values for the radiation may be 200 W and 1 000 W, the limiting values for the ambient temperature may be 5°C and 30°C and the limiting values for the speed may be 20 km/h and 80 km/h. However, this values are vehicle-dependent and may be significantly higher in very comfortable vehicles.